Results of the Alpha-Particle-X-ray Spectrometer on Board of the Mars Exploration Rovers. R.Gellert[1], J. Zipfel[1], J.Brückner[1], G. Dreibus[1], G. Lugmair[1], R. Rieder[1], H. Wänke[1], G. Klingelhöfer[2], B. C. Clark[3], D. W. Ming[4], A. Yen[5], S. Squyres[6], and the Athena Science Team, [1]Max-Planck-Institut für Chemie, J. J. Becher Weg 27, D-55128 Mainz, Germany, e-mail: gellert@mpch-mainz.mpg.de, [2]Instit. f. Anorgan. Analyt. Chemie, Univ. of Mainz, Germany, [3]Lockheed Martin Corp., Littleton, CO, USA, [4]Johnson Space Center, Houston, TX, USA [5]Jet Propulsion Lab., Pasadena, CA, USA, [6]Center f. Radiophys. Space Res., Cornell University, Ithaca, NY, USA.

Overview: The Mars Exploration Rovers Spirit and Opportunity landed at Gusev crater and Meridiani Planum [1]. The Alpha Particle X-ray Spectrometer (APXS) is part of the instrument suite on both rovers [2]. It is equipped with six ^{244}Cm sources which provide x-ray excitation with alpha-particles (PIXE) and x-ray radiation (XRF). This combination allows x-ray spectroscopy of elements from Na to Br in the energy range of 0.9 to 16 keV. X-ray detectors with a high energy resolution of 160 eV at Fe Kα allow us to separate even closely spaced energy peaks, such as Na, Mg, Al and Si. The APXS is attached to the rover's arm and provides in-situ measurements of the chemical composition of soils, surfaces of rocks and outcrops and their abraded surfaces [3,4].

This abstract gives an overview of APXS results obtained during the first year of operation on both landing sites.

Meridiani and Gusev soils: Soils at Meridiani Planum can be interpreted as a mixture of two components [5]. One is a basaltic, fine grained soil component which is globally distributed on Mars as inferred by its very similar composition to soil at other Martian landing sites, Viking 1 and 2, Pathfinder, and Gusev crater. This component is characterized by high and variable concentrations of S and Cl with a remarkably constant S/Cl ratio of approximately 5. The second component is spherules and angular fragments of 1 to 6 mm in size. This component is rich in Fe and has a high Fe/Mn ratio as deduced from measurements of samples with different aerial coverage. This indicates the presence of Fe in the Fe^{3+} oxidation state, in agreement with the detected high hematite content obtained by the Mossbauer Spectrometer [6]. This second component is absent in Gusev crater soils.

Layering of the soil was investigated using the rover wheels. Soil analyses of wheel tracks and undisturbed soil surfaces do not show any significant compositional differences. However, in ~ 10 cm deep trenches at Meridiani, dug with the wheels, typically the spherule content is lower and Br has increased relative to Cl. One trench in the plains at Gusev crater shows a correlated increase of Mg and S, indicating the presence of Mg-sulfate in subsurface layers. In addition, the Br/Cl and S/Cl ratios increase inside the trench indicating a decoupling of these soluble elements at subsurface layers. Systematic soil measurements during a 3 km traverse showed no significant change although the local rocks are different (Fig. 1).

Meridiani outcrop: Composition of outcrop rocks exposed in three impact craters at Meridiani Planum was investigated. Most analyses were taken after rock surfaces were abraded in order to eliminate surface contamination. These rocks have a relatively uniform composition, characterized by a very high S content, assumed to be SO_3. This indicates the presence of up to 40 wt. % sulfate salts, mainly Mg-sulfate. After subtracting S the remaining elemental composition reveals a strong resemblance to the average soil composition distinct only in higher Mg, P and K. The strong enrichment in S, decoupling of S and Cl and variable and high enrichments of Br versus Cl give evidence that these bedrocks formed under aqueous conditions. Exploring the larger Endurance crater, APXS analyses of the exposed bedrocks revealed a stratigraphic layering of the sediments. The topmost layer is close in composition to bedrocks analyzed in the smaller craters Eagle and Fram. Lower layers show an increase in Cl concentrations by nearly a factor of 3. In even lower layers Mg and S are correlated and infer depletion in Mg-sulfate compared to the top layers by approximately 20 %. This depletion is compensated by an increase in Si and Al (Fig. 2). In the lowest accessible area of Endurance crater very high concentrations of ~ 1500 ppm Br were detected.

Gusev rocks: Rocks, Adirondack, Humphrey and Mazatzal, on the plains of Gusev crater are Mg-rich primitive basalts. They are covered to variable degrees by surface coatings and/or alteration rinds. One rock named Mazatzal has a surface coating rich in Cl, K, P and Ni. High Br concentration in analysis of the interior after abrasion of the surface can be attributed most probably to a vein visible in MI images [7].

After a 3 km traverse the rover reached the base of the Columbia Hills, called West Spur. Here for the first time Spirit encountered bedrock. The investigated rocks differ in composition from the basaltic rocks on the plains by having higher Mg and Ti, and lower Ca and Cr contents (Fig. 1). These bedrocks are highly variable in composition even on a scale of 10 cm. Surface concentrations of Br are very high and variable. In addition, after abrading up to 9 mm of the surface high concentrations of elements typical for alteration, such as S, Cl and Br, were measured.

On the way to the top of the Columbia Hills, Spirit passed a lower lying saddle covered with a new rock type. APXS analyses of three such rocks, among them Wishstone, show spectra with a remarkably unique basaltic signature. These rocks are extremely high in P, which reaches 5.5 wt. % P_2O_5 in the abraded interior. A correlated increase of P and Ca after brushing and abrading implies the presence of up to 13 wt. % apatite. The CIPW norm calculations give a mineralogy that is dominated by plagioclase. For the first time traces of Pb, As, and either Rb or Y, elements compatible with apatite and plagioclase, could be detected (Fig. 3). These rocks also have high Ti (~ 2.5 wt. % TiO_2), which is 3 times higher than the concentration of West Spur bedrocks and the Gusev crater plains basalts.

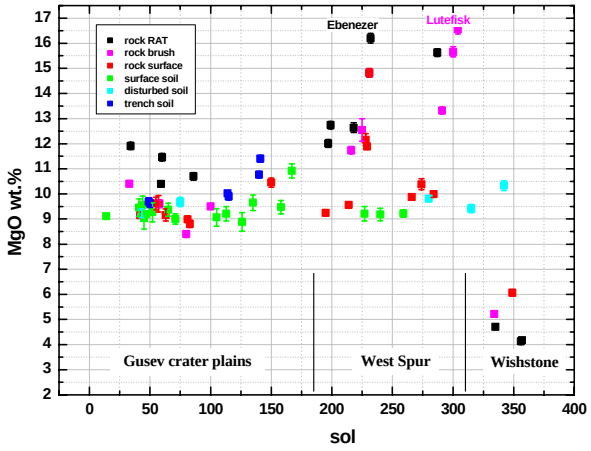

Fig. 1 Rover traverse over the last year. Changes in MgO wt. % concentrations characterize the encountered rock types in different terrains. Soil composition remains constant.

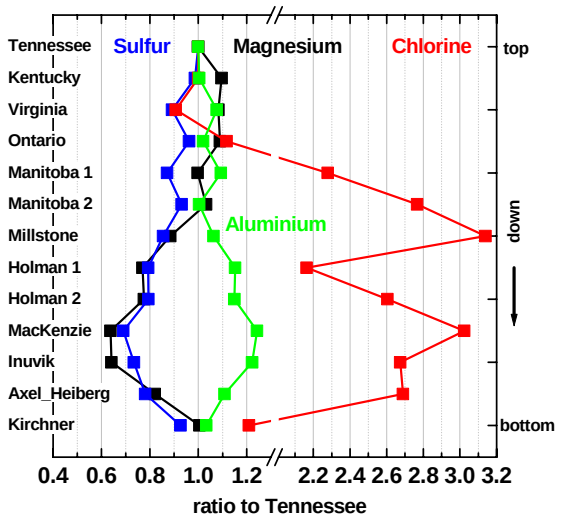

Fig. 2 Chemical changes in abraded Endurance crater outcrop rocks imply a stratigraphic layering of the sediments. Note the difference in onset of increase in Cl and depletion of Mg-sulfate.

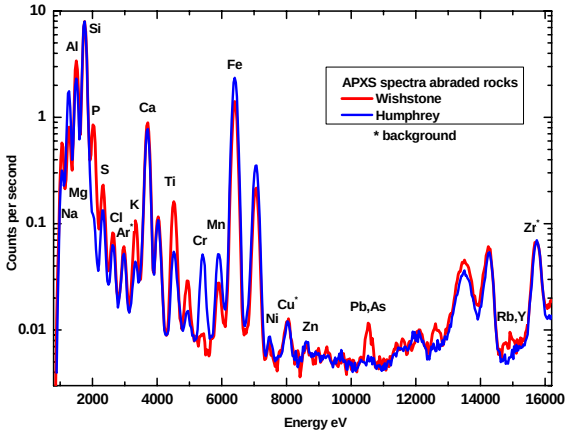

Fig. 3 Comparison of APXS spectra of Wishstone and Humphrey, a typical primitive basalt in the plains. Abundances of nearly all elements change by 50 % or more.

References: [1] Squyres, S.W., et al. (2003) *JGR, 108(E12),* 8062. [2] R. Rieder et al. (2003) *JGR, 108(E12),* 8066. [3] Gellert, R. et al. (2004) *Science, 305,* 829-832. [4] Rieder, R. et al. (2004) *Science, 306,* 1746-1749. [5] Soderblom, L. A. et al. (2004) *Science, 306,* 1723-1726. [6] Klingelhöfer, G. et al. (2004) *Science, 306,* 1740-1745. [7] Herkenhoff, K. E. et al. (2004) *Science, 305,* 824-826.